Virialization of the Broad Hα Emission Region in Active Galactic Nuclei Type 1

Sladjana Marčeta-Mandić[1,2], Jelena Kovačević-Dojčinović[2] & Luka Č. Popović[1,2]

[1]Mathematical Faculty, University of Belgrade, 11000 Belgrade, Serbia;
[2]Astronomical Observatory, Volgina 7, 11060 Belgrade, Serbia

email: sladjana@aob.rs

Abstract

Here we investigate the virialization of the broad Hα emission region using the sample of 68 Type 1 Active Galactic Nuclei (AGN) taken from the Sloan Digital Sky Survey (SDSS). This was done by comparing kinematical parameters of the broad Hα lines with those of the broad Hβ, for which it is assumed that are originating from the virialized emission region. Our results are indicating that other mechanisms should be responsible for the Hα profile broadening and asymmetry, besides black hole gravitation, i.e. the broad Hα emission region is probably not with the same geometry as Hβ one.

1. Introduction

AGN is a compact region in the center of a galaxy with a luminosity over 10^4 higher than those of a normal galaxy, which is attributed to the accretion of gas into the super-massive black hole (SMBH) ($10^6 - 10^{10} M_\odot$). Most of the AGNs have a similar structure [1]: SMBH in its center is surrounded by a geometrically thin and optically thick accretion disc (AD) which expands into a dusty torus. Above and below the AD spreads the broad line region (BLR), with optically thick gas, where broad emission lines (BEL) arise [2]. Gas in the BLR is ionized by the continuum radiation emitted from the AD and influenced by the gravitational field of SMBH, which causes complexity of structure and kinematics of BLR and affects BELs shapes [3].

As BEL are originating from the regions close to the SMBH, it is assumed that the BLR emission gas kinematics is virialized and that such, Keplerian-like motion of the gas broadens BEL profiles. Based on the virial theorem, the Full Width at Half Maximum (FWHM) of the broad Hβ line is most frequently used for $M_{\rm BH}$ estimation [4, 5]. Also, there is an assumption that the red asymmetry frequently seen in the broad Hβ line profile can be caused by the gravitational redshift (GR), and it can be $M_{\rm BH}$ indicator as well [6].

Several authors [7, 8, 9] used the FWHM of Hα line as a virial estimator of $M_{\rm BH}$, relying on the high correlation of the broad Hα FWHM and the broad Hβ FWHM. They assume that these two lines have similar profiles, and that Hα region is virialized as Hβ ones. However, there are some indications that broad Hα profiles can be affected by the starburst-driven galactic winds [10] or by AGN outflows [11]).

We investigate: (A) if the assumption that the Hα and the Hβ BEL profiles are similar is correct; (B) if the broad Hα line is virialized as the Hβ is, and (C) is there an influence of the GR to the broad Hα line profile. We compared the Hα and the Hβ BEL profiles, and the correlations between kinematical line parameters.

2. The Sample and Analysis

We used the sample of 68 AGNs Type 1 spectra taken from the SDSS, analyzed in [12] and [13], corrected for the Galactic extinction, cosmological redshift, host galaxy contribution and continuum emission.

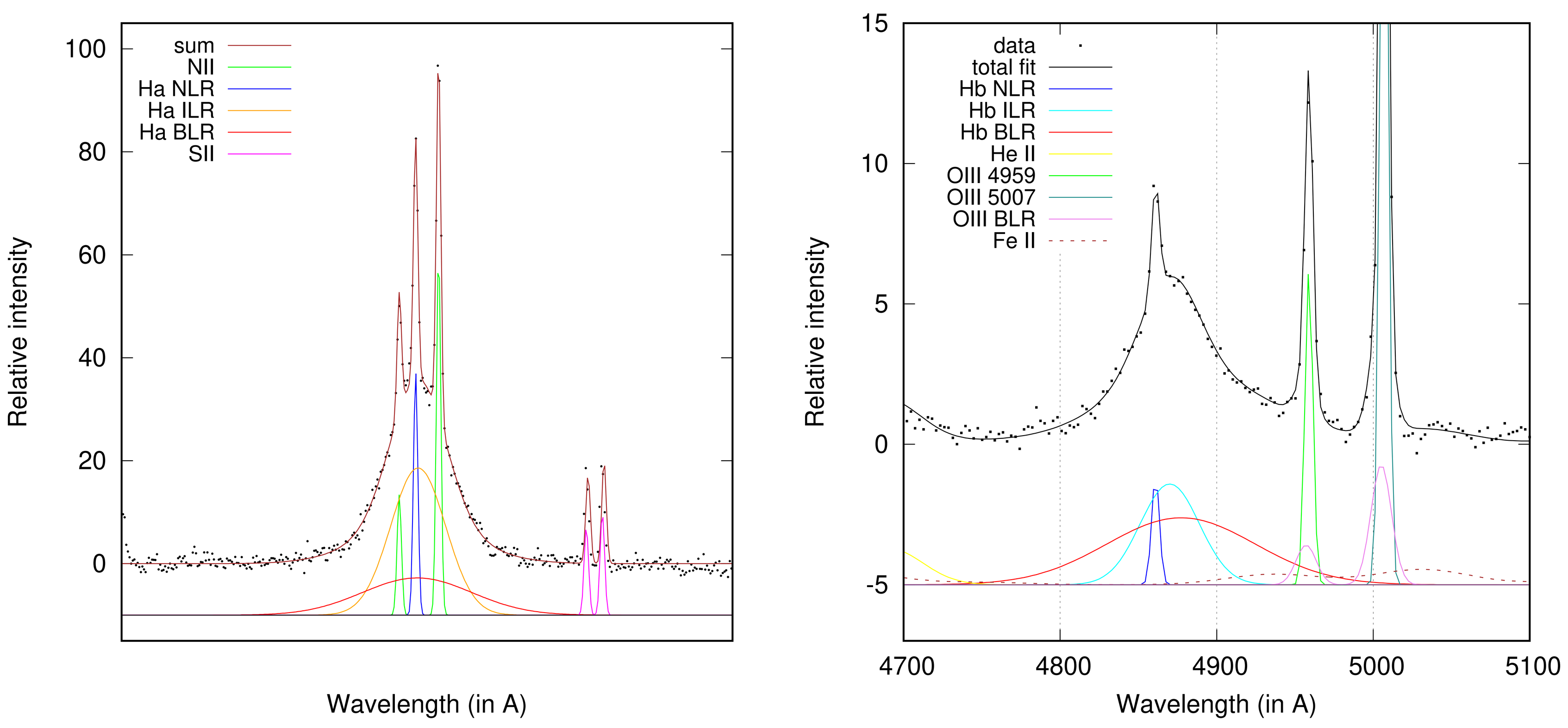

Figure 1. The examples of the decomposition of the Hα and Hβ for object 0439-51877-0566, decomposed to one narrow and two broad Gaussians.

The spectra were fitted using the multi-Gaussian model of optical emission, and the BLR emission is described with the two-component model: very broad line region (VBLR) closer to the SMBH, and intermediated line region (ILR), as it was described in [14]. As shown in Fig. 1. the BEL profile is obtained as a sum of two broad Gaussians, and afterward, the FWHM and asymmetry (intrinsic redshift, z_{50}) of the BEL are measured as shown in Fig. 2. The z_{50} is measured as a difference between the centroid shift and the broad component peak at 50% of I_{max} (see [15]).

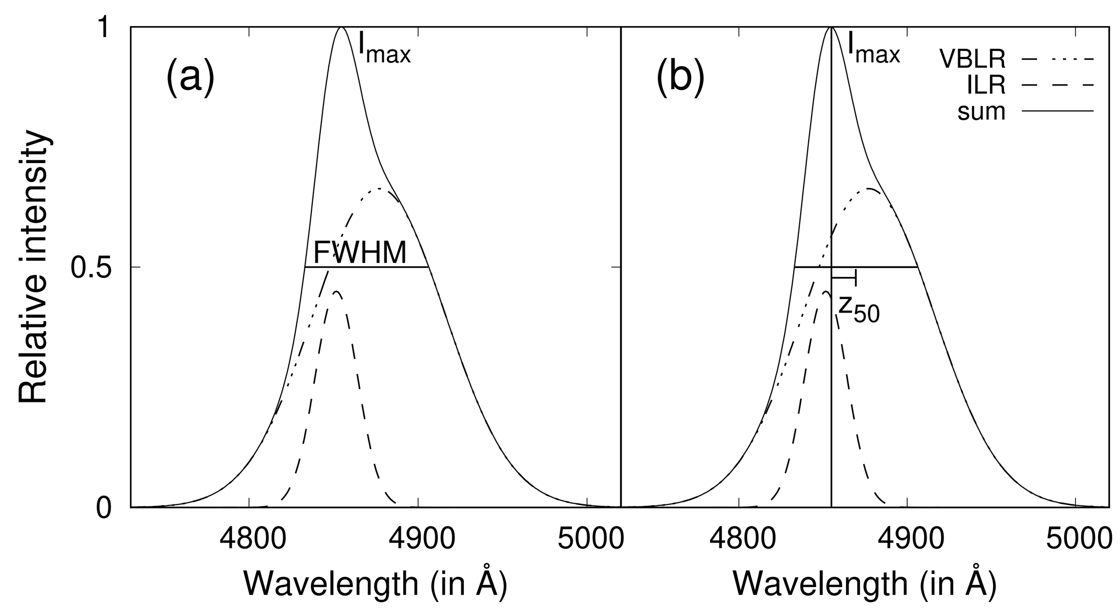

Figure 2. An example of measuring FWHM (a) and intrinsic redshift z_{50} (b) of the broad line component (VBLR + ILR).

3. Results

The mean Hα profile is narrower than Hβ one (Fig. 3, left), which may indicate that broad Hα arises in the emission region further away from the SMBH than Hβ emission region. Mean Hα profile shows no asymmetry while mean Hβ profile has red asymmetry indicating a possible influence of the GR.

If line emitting region is virialized and if influence of GR is not negligible [16], the $FWHM^2$ and the z_{50} of the lines are expected to be linearly correlated. For the Hα profiles there is no such a correlation (ρ=-0.09, P_0=0.44), while for the Hβ this correlation is significant (ρ=0.69 and $P_0 = 9 \cdot 10^{-11}$) (Fig. 3, right).

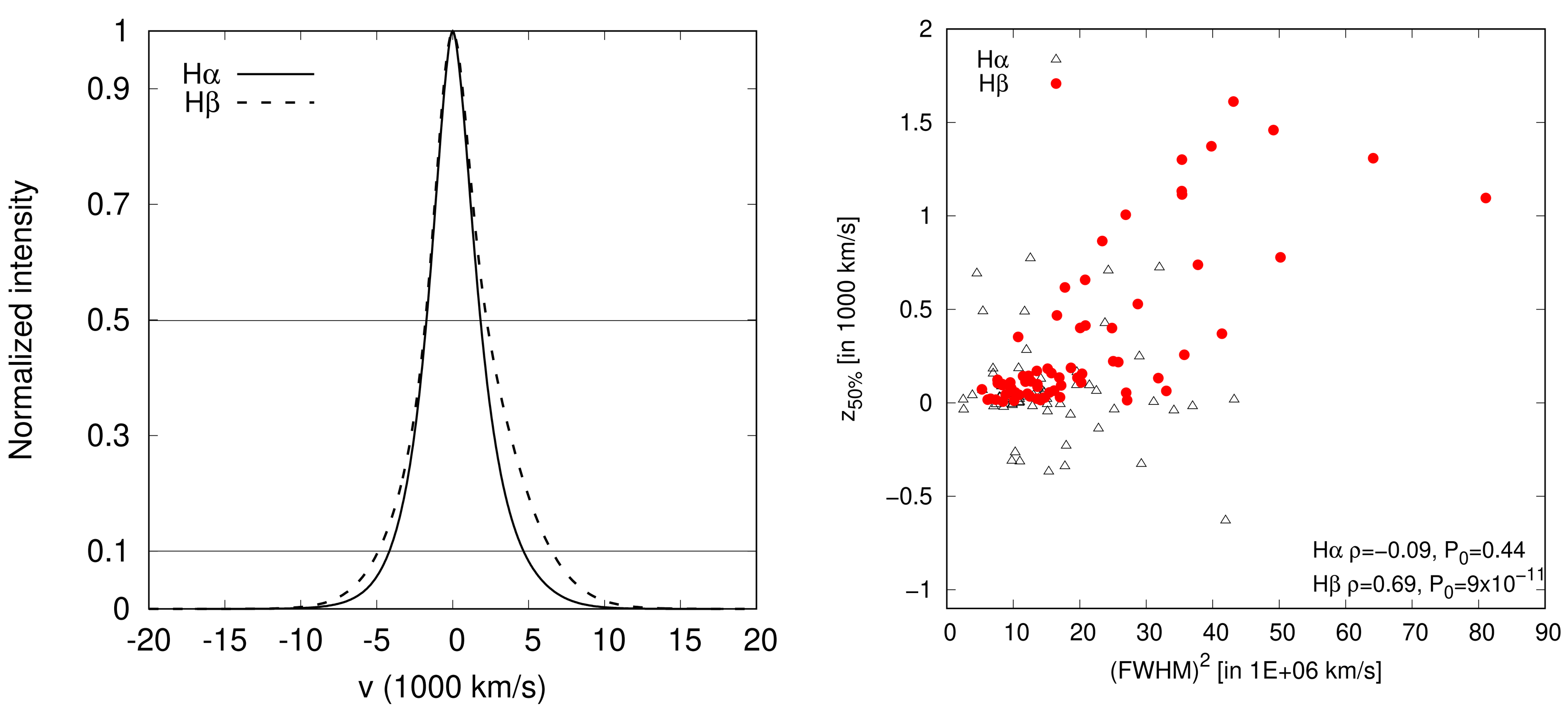

Figure 3. *Left:* Mean normalized profiles for Hα and Hβ. *Right:* The relationship between the $FWHM^2$ and z_{50}. The triangles: Hα, circles: Hβ.

As it can be seen in Fig. 3 (left) the difference between the mean Hα and Hβ line profiles in the red wing indicates that the geometry of the broad Hα and Hβ emission region is not the same. The non-existence of the correlation between the Hα FWHM and Hα z_{50} indicates that these two line features probably are not influenced by the same physical mechanism in the case of the Hα line.

It seems that other mechanisms should be partly responsible for the Hα profile broadening and asymmetry, such as AGN outflows or starburst-driven galactic winds (as suggested i.e. in [10]), unrelated to the dominant influence of SMBH. Thus, the Hα line emitting region is probably less virialized than Hβ one, and the effect of the GR is not observed in the Hα broad profiles in this sample.

4. References

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